Exhibit 8

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Is Passenger Vehicle Incompatibility Still a Problem?

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Objective: *Passenger cars often are at a disadvantage when colliding with light trucks (sport utility vehicles [SUVs] and pickups) due to differences in mass, vehicle structural alignment, and stiffness. In 2003, vehicle manufacturers agreed to voluntary measures to improve compatibility, especially in front-to-front and front-to-side crashes, with full adherence to be achieved by September 2009. This study examined whether fatality rates are consistent with the expected benefit of this agreement.*

Methods: *Analyses examined 2 death rates for 1- to 4-year-old passenger vehicles during 2000–2001 and 2008–2009 in the United States: occupant deaths per million registered vehicle years in these vehicles and deaths in other cars that collided with these vehicles in 2-vehicle crashes per million registered vehicle years. These rates were computed for each study period and for cars/minivans (referred to as cars), SUVs, and pickups by curb weight (in 500-pound increments). The latter death rate, referred to as the car crash partner death rate, also was computed for front-to-front crashes and front-to-side crashes where the front of the 1- to 4-year-old vehicle struck the side of the partner car.*

Results: *In both study periods, occupant death rates generally decreased for each vehicle type both with increasing curb weight and over time. SUVs experienced the greatest declines compared with cars and pickups. This is due in part to the early fitment of electronic stability control in SUVs, which drastically reduced the incidence of single-vehicle rollover crashes. Pickups had the highest death rates in both study periods.*

Car crash partner death rates generally declined over time for all vehicle categories but more steeply for SUVs and pickups colliding with cars than for cars colliding with cars. In fact, the car crash partner death rates for SUVs and cars were nearly identical during 2008–2009, suggesting that the voluntary design changes for compatibility have been effective. Car crash partner death rates also declined for pickups, but their rates were consistently the highest in both study periods.

Conclusion: *It is impossible to disentangle the individual contributions of the compatibility agreement, improved crashworthiness of cars, and other factors in reducing car crash partner fatality rates. However, the generally larger reductions in car crash partner death rates for SUVs and pickups indicate the likely benefits of the agreement. Overall, this study finds that the system of regulatory testing, voluntary industry initiatives, and consumer information testing has led to a passenger vehicle fleet that is much more compatible in crashes.*

Keywords Compatibility; Aggressivity; Crashworthiness; EVC; Light trucks; Passenger vehicles

INTRODUCTION

Passenger vehicles are subject to a myriad of federal and consumer information crash tests designed to ensure high levels of occupant protection in these crash conditions. *Vehicle compatibility* refers to the ability of 2-vehicle crashes to result in occupant protection in both vehicles that would be predicted by the test scenarios for which they are designed. Vehicles are considered incompatible in front-to-front and front-to-side crashes when differences in mass, vehicle structural alignment, and stiffness exist. In particular, passenger cars often are at a disadvantage when colliding with light trucks (sport utility vehicles [SUVs] and pickups), which tend to be heavier, taller, and have stiffer front structures.

Mass incompatibility is governed by basic physics. In 2-vehicle crashes between vehicles with disparate mass, both vehicles experience the same forces at the crash interface; however, the lighter vehicle will experience higher acceleration due to its lower mass. This translates to higher accelerations of the occupants inside the light vehicle, which in turn increases occupant injury risk. Mass incompatibility can be mitigated with advanced occupant protection measures but can never be eliminated.

Occupant protection in frontal crashes is regulated by the U.S. government in 56 km/h frontal impacts into a rigid wall both head-on and at a 30-degree angle. In these tests, the rigid wall extends laterally and vertically to engage the entire front structure of all passenger vehicles. The result is that a vehicle's front structure, regardless of its lateral or vertical positioning, is

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guaranteed to interact with a reaction surface of virtually infinite stiffness. This means that manufacturers can utilize any type and location of front structure to control and absorb crash energy to protect the occupants in the vehicle.

The flat wall impact is an idealized scenario intended to represent a vehicle striking itself with perfect mirror-image alignment, something that rarely occurs in real-world crashes. Instead, in frontal crashes involving 2 vehicles, the stiff, energy-absorbing elements of each vehicle often do not meet. This can occur as a result of lateral mismatch of structural elements, when the structures bypass each other instead of meeting head on, or vertical mismatch, when the structures override and underride each other. The latter scenario often occurs in crashes between light trucks and passenger cars. SUVs and pickups are exempt from federal bumper standards and typically have front structures and ride heights higher than cars, in part to provide some off-road functionality. When mismatch occurs, some energy-absorbing front structures are underutilized and the crash forces are not ideally managed. This can lead to excessive intrusion into the occupant compartment in severe crashes.

In part to address the limitations of flat barrier testing, the Insurance Institute for Highway Safety (IIHS) evaluates frontal crash protection in a 64 km/h impact into an aluminum-honeycomb deformable barrier mounted to a rigid barrier where only 40 percent of the vehicle front end engages the barrier. The deformable barrier is intended to roughly replicate the types of soft structures on the front of other vehicles and helps encourage front-end structural designs to be less reliant on the specific construction of the opposing vehicle to ensure good occupant protection. The offset loading also encourages front structural designs to be linked laterally, typically with fairly stout cross-members, so that crash forces on one side of the vehicle are also directed toward the other, which should improve the vehicle's ability to interact well with a variety of other vehicle designs. Strong performance in this test has been linked to lower driver death risk in 2-vehicle crashes (Farmer 2005).

Though the IIHS frontal offset test has helped discourage lateral mismatch, it does not address vertical mismatch or stiffness mismatch. With regard to the latter, it is important to note that both the IIHS and federal tests are conducted at fixed impact speeds. This can result in heavy vehicles being designed with very stiff front energy-absorbing structures to help them manage the higher kinetic energy that results from their greater mass at a fixed velocity. Conversely, lighter vehicles must manage a lesser amount of kinetic energy, so their front structures typically are not as stiff. Stiffness mismatch can result in one vehicle's crush zone being consumed before utilizing much of the other vehicle's crush zone. Automakers could reduce or completely eliminate stiffness incompatibility by designing vehicles with front crush zones of varying lengths, holding the stiffness constant for all vehicles. However, this is rarely done because of the practical limitations on vehicle length, mass, and styling. Stiffness has been shown to contribute to incompatibility, although its effects are shown to be most relevant when the structures are geometrically aligned (Meyerson and Nolan 2001).

Whereas these crash tests suggest some challenges of addressing incompatibility in front-to-front crashes, front-to-side crashes represent an even bigger challenge in incompatibility in terms of geometry and stiffness. The sides of passenger vehicles have relatively little space to absorb impact forces while limiting occupant compartment intrusion. When the striking vehicle is a light truck, the geometric compatibility is further degraded due to the higher hood heights of these vehicles, which often are high enough to make direct contact with car occupants' heads (Monk and Willke 1985; Nolan et al. 1999). Mass incompatibility is especially pronounced in side-struck cars (Crandall 2003). Side air bags, especially those that protect both the head and torso, have been shown to greatly reduce driver death risk in side-impact crashes (Braver and Kyrychenko 2004; Kahane 2007; McCartt and Kyrychenko 2007). To address the problem of height mismatch in side crashes, in 2003 the IIHS began conducting a new side crash test using a movable deformable barrier designed to simulate the front of a typical light truck. This crash test was designed to encourage side air bags and structural changes to mitigate the fundamental incompatibility that occurs when struck on the side. Good performance in the IIHS side crash test, especially in terms of good structure rating, has been shown to greatly reduce occupants' risk of dying in side-impact crashes in vehicles equipped with standard side air bags protecting both the head and torso (Teoh and Lund 2011).

The proliferation of SUVs in the 1990s led researchers to investigate how these vehicles interacted with cars in crashes. Numerous studies of frontal fatal and injury crashes and controlled crash tests found that the higher structures of most SUVs were incompatible with car structures, resulting in SUVs overriding their car crash partners (Gabler and Hollowell 1998, 2000; Meyerson and Nolan 2001; Nolan et al. 1999; Wykes et al. 1998). Override of a car's front structure does not fully utilize the car's energy absorption capability and in severe crashes leads to intrusion into the car occupant space. It was estimated that the incompatibility of light trucks with cars, also termed *aggressivity*, made it up to 6 times more likely that occupants of cars would die in crashes with light trucks than in crashes with other cars. Though side-impact crashworthiness of cars improved from model years 1980–1989 to 1997–2001 and their aggressivity in side-impact crashes remained largely unchanged, aggressivity of light truck vehicles when striking cars on the side actually increased during these model years (Gabler 2003).

O'Neill and Kyrychenko (2004) studied both the crashworthiness, or self-protection, and aggressivity of cars/minivans (hereafter referred to as cars), SUVs, and pickups. The study evaluated changes in newer passenger vehicles over a decade. It concluded that large improvements in both self-protection and aggressivity were achieved between 1990–1991 and 2000–2001 but that incompatibility between SUVs and pickups still existed, in some cases quite significantly for pickups. These improvements were further demonstrated by Braitman et al. (2007). Although this finding indicated that the fleet was becoming more compatible, it also suggested that more needed to be done.

In 2003, the National Highway Traffic Safety Administration (NHTSA) convened a meeting of all of the major automakers, IIHS, and other experts in the field to encourage the industry to enact voluntary guidelines to improve passenger vehicle compatibility. The result was the formation of the Enhancing Vehicle Compatibility (EVC) group. The EVC divided its efforts into 2 parts: front–front crashes and front–side crashes (Alliance of Automobile Manufacturers 2003).

For front–side crashes, The EVC quickly deemed that the gross structural and stiffness incompatibility between the fronts of light trucks and the sides of passenger cars needed countermeasures on both cars and light trucks. For cars, the EVC in essence agreed to fit head-protecting side air bags on all passenger vehicles by September 2009, with a 50 percent adherence target by September 2007. Manufacturers verified adherence with the voluntary agreement initially by ensuring good head protection in NHTSA's Federal Motor Vehicle Safety Standard (FMVSS) 201 side pole crash test, in which the vehicle travels laterally at 18 mph into a pole with the driver dummy's head aligned with the pole. After 2007, the automakers also agreed to certify adherence by providing good head protection in the IIHS side crash test with a moving SUV barrier. For the fronts of light trucks, the front–side group relied on the efforts of the front–front group to lower the front structure of these vehicles, which has been shown to significantly reduce injury risk for struck-side occupant crash tests (Nolan et al. 1999; Seyer et al. 2000).

For the front–front crash effort, the EVC concluded from the existing body of controlled crash test research that the primary focus on improving light truck compatibility with cars should be to ensure that geometrical structural incompatibility was improved. There was little real-world data indicating that lateral structural mismatch was a big contributor toward vehicle incompatibility. However, significant data existed indicating that vertical structural mismatch was a problem. All cars are subject to FMVSS 581, the bumper standard and, as such, the primary energy-absorbing structures of cars share a common height from the ground. The regulated 581 bumper impact is 16 to 20 inches from the ground and provides a convenient target for light trucks to match. After much discussion and research, the EVC agreed that the primary front structures of light trucks should overlap at least half of the federal bumper zone. If that were not possible due to the vehicle's functional requirements, a secondary load path would be created within 400 mm rearward of the leading edge of the light truck, fully encompassing the federal bumper zone for cars. Such a design was pioneered by Ford and trademarked as BlockerBeam. Light truck–to-car tests were conducted with and without both types of countermeasures and showed that they dramatically reduced the threat to car occupants (Barbat et al. 2007; Summers et al. 2003). By 2004, about half of light trucks met one of these voluntary design specifications. Adherence increased to 62 percent in 2005, 75 percent in 2006, and 81 percent in 2007. The agreement stipulated that there would be full light truck adherence by September 2009.

Baker et al. (2008) studied the difference in car fatality rates between cars struck by light trucks meeting the EVC guidelines and those struck by light trucks not yet complying. The car driver fatality rate was 19 percent lower for front-to-front crashes when the light truck involved complied with the voluntary standards than when it did not. The fatality rate also was 19 percent lower when the car was struck on the driver's side. These findings are consistent with results of controlled side crash tests that altered the ride heights of striking vehicles and found large reductions in lateral intrusion and struck vehicle occupant injury measures (Lund et al. 2000; Nolan et al. 1999; Seyer et al. 2000). Door sills are one of the primary lateral structures on cars, so striking a car nearer the sill produces less intrusion than striking farther vertically from the strong structure.

The purpose of the current study was to determine whether fatality rates for occupants of cars in 2-vehicle collisions are consistent with the expected benefit of this agreement estimated by O'Neill and Kyrychenko (2004) and Baker et al. (2008).

METHODS

Analyses examined the rate of occupant crash deaths per million registered vehicle years during the years 2000–2001 and 2008–2009. Data on fatally injured passenger vehicle occupants were extracted from the Fatality Analysis Reporting System, an NHTSA-maintained census of fatal crashes on U.S. public roads, for the study years, and exposure was taken as counts of registered vehicle years calculated with data available from R.L. Polk and Company which is based in Southfield, MI and offers annual registration counts at the make/model/model year level. Whereas O'Neill and Kyrychenko (2004) focused their analyses on model years 1987–1989 involved in fatal crashes during 1990–1991 and model years 1997–1999 involved in fatal crashes during 2000–2001 (all of which were 1–4 years old during their study periods), the present study considered all 1- to 4-year-old passenger vehicles during 2000–2001 and 2008–2009. This was a minor difference that simplified the presentation of results.

For each study period, 2 death rates were computed for 1- to 4-year-old cars, SUVs, and pickups for different curb weight categories (500-pound increments). Stratifying by curb weight largely controls for mass differences among vehicle types. The first death rate was a measure of self-protection of occupants (or crashworthiness) and counted deaths of occupants in the vehicle in all types of crashes. The second rate was a measure of aggressivity and counted deaths of occupants in other cars involved in these crashes, including all model years and curb weights. Though the concept of aggressivity can apply to multiple-vehicle crashes, the latter rate focused only on 2-vehicle crashes due to the complexity and relative infrequency of fatal crashes involving 3 or more vehicles. The death rate measuring aggressivity is referred to as the *car crash partner death rate* in this study.

Consider, for example, 1- to 4-year-old SUVs weighing 3500 to 3999 pounds. For these vehicles, the occupant death rate is calculated as the number of deaths in these SUVs (times 1,000,000) divided by the number of registered vehicle years of such SUVs. The car crash partner death rate is calculated as the

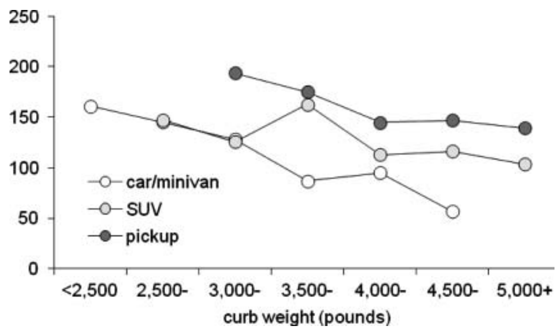

Figure 1 Occupant deaths in 1- to 4-year-old cars, SUVs, and pickups per million registered vehicle years during 2000–2001.

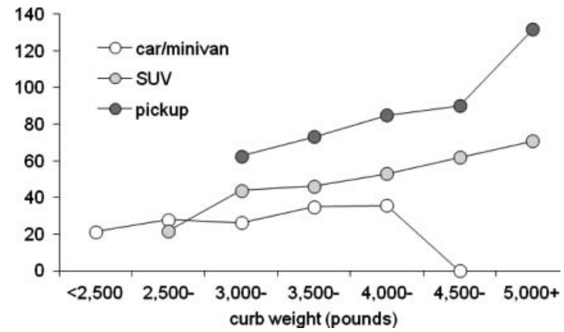

Figure 3 Car crash partner deaths in 1- to 4-year-old vehicles per million registered vehicle years during 2000–2001.

number of car occupant deaths in 2-vehicle crashes with 1- to 4-year-old, 3500- to 3999-pound SUVs (times 1,000,000) divided by the number of registered vehicle years of such SUVs. To eliminate overly imprecise estimates, death rates were presented only for vehicle categories with more than 100,000 registered vehicle years in each study period.

Two important components of the overall car crash partner death rate also were computed by restricting to front-to-front crashes and to crashes where car crash partner vehicles were struck on the side by the fronts of 1- to 4-year-old passenger vehicles. In particular, these are the 2 primary mechanisms by which compatibility problems of SUVs and pickups, beyond weight differences, may cause harm to car occupants. In the Fatality Analysis Reporting System, frontal impacts were defined as principal impact clock points 11, 12, and 1 and side as clock points 2, 3, 4, 8, 9, and 10.

Many things unrelated to vehicle incompatibility have changed between the study periods. Though it is not possible to control for all confounders, their effect was minimized by treating 1- to 4-year-old cars as a comparison group. For example, if measures to reduce incompatibility between SUVs and cars are effective, then that should result in a reduction in the car crash partner death rate of 1- to 4-year-old SUVs. However, other factors may reduce that rate as well, such as changes in vehicle use patterns, changes in belt use, and improved crashworthiness of the car fleet. But those also would affect the car crash partner death rate of 1- to 4-year-old cars. So comparing the car crash partner death rate of 1- to 4-year-old vehicles with that of 1- to 4-year-old cars within the time period largely controls for factors unrelated to incompatibility.

RESULTS

Figures 1 and 2 present the rate of occupant deaths per million registered vehicle years for 1- to 4-year-old passenger vehicles in 2000–2001 and 2008–2009, respectively. Occupant death rates declined for all vehicle categories between these time periods, with SUVs experiencing the greatest declines compared to cars and pickups. For example, for vehicles with curb weights of 3000 to 3499 pounds, the death rate for SUVs fell by 50 percent (from 126 to 62 deaths per million registered vehicle years), compared to 29 percent for cars (from 128 to 91 deaths) and 25 percent for pickups (from 194 to 145 deaths). In both study periods, occupant death rates also generally declined with increasing curb weight for each type of vehicle. Pickups had higher death rates than cars or SUVs in both study periods, whereas the large decrease in occupant death rates for SUVs resulted in lower death rates than cars for all but the lightest SUVs by 2008–2009.

Figures 3 and 4 present the car crash partner death rates in 2000–2001 and 2008–2009, respectively, for collisions with SUVs, pickups, and cars. In both timeframes and for all vehicle types, the car crash partner death rates generally increased as the curb weight of the SUV, pickup, or car increased.

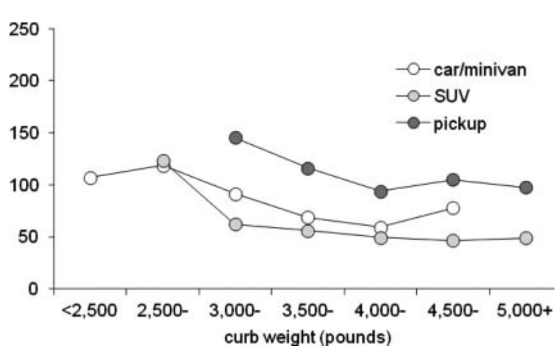

Figure 2 Occupant deaths in 1- to 4-year-old cars, SUVs, and pickups per million registered vehicle years during 2008–2009.

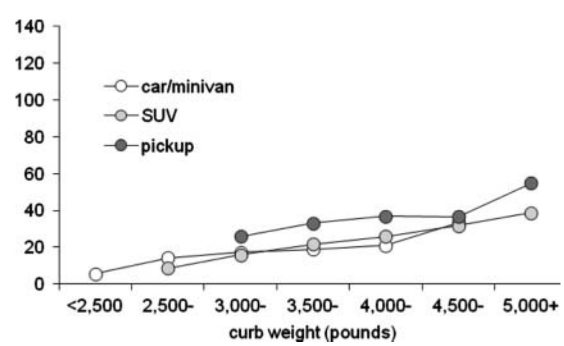

Figure 4 Car crash partner deaths in 1- to 4-year-old vehicles per million registered vehicle years during 2008–2009.

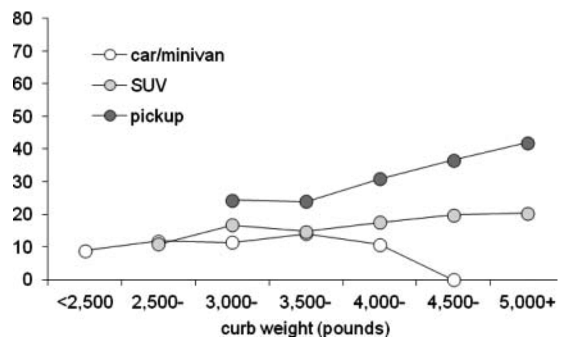

Figure 5 Car crash partner deaths in front-to-front collisions for 1- to 4-year-old vehicles per million registered vehicle years during 2000–2001.

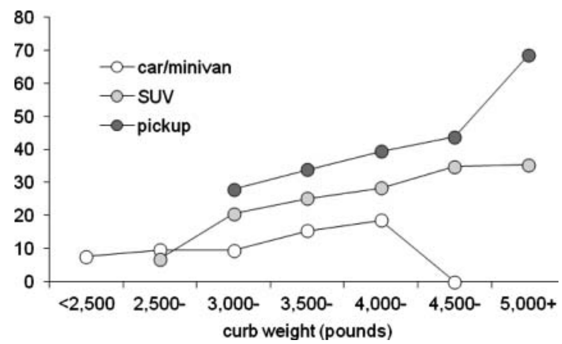

Figure 7 Car crash partner deaths in front-to-side-of-car collisions for 1- to 4-year-old vehicles per million registered vehicle years during 2000–2001.

The rate of car crash partner deaths has declined over time for all vehicle categories (with the exception of the relatively small category of 4500- to 4999-pound cars) but more steeply for SUVs and pickups. For example, among vehicles weighing 3000 to 3499 pounds, this rate declined 63 percent for SUVs (from 44 to 16 car partner occupant deaths per million registered vehicle years of 1- to 4-year-old SUVs), 58 percent for pickups (from 63 to 26 deaths), and 34 percent for cars (from 26 to 17 deaths). The overall variation in this rate among the 3 vehicle types was far smaller in 2008–2009 compared to 2000–2001. In fact, the rates for SUVs and cars were nearly identical during 2008–2009, whereas the rate for SUVs was higher in 2000–2001 for all curb weights of 3000 pounds and greater. The rates for pickups were consistently higher than those for SUVs or cars during both study periods, although less so during 2008–2009.

In terms of causing harm to car occupants, SUVs have become more similar to cars when striking cars on both the front (Figures 5 and 6) and side (Figures 7 and 8) than they were in the past, controlling for weight category. Pickups generally still were more aggressive, particularly for front-to-front crashes. Of note is the reduction in the SUV rates in Figure 8 compared to the 2000–2001 numbers in Figure 7.

DISCUSSION

The intent of this study was to evaluate the aggressivity of modern light trucks and cars, especially in front and side crashes, with cars over time. Based on comparisons of vehicles within the same weight categories, the findings show that the issue of incompatibility of SUVs with cars and, to a lesser extent, the incompatibility of pickups with cars largely has been ameliorated. However, SUVs and pickups tend to be heavier than cars. Though this fundamental incompatibility remains, reducing incompatibility within weight groups is an important first step. It is likely that a large factor in the reduced aggressivity of light trucks is the increased adherence with the EVC compatibility design guidelines. In 2004, the first reporting year for EVC, only 24 percent of vehicles met the front–side guidelines and 54 percent met the front structural matching guidelines. These figures increased to 71 and 81 percent by 2007, respectively. One hundred percent adherence was achieved in 2009. These light truck design changes have been shown by Baker et al. (2008) to reduce partner car driver fatality rates in front-to-front and front-to–driver side crashes, each by 19 percent. However, at the same time, the self-protection in both front and, more notably, side crash protection of cars is reducing their vulnerability, especially when struck in the side by light trucks. Based on the IIHS side crash test simulating a light truck colliding into the side of a vehicle, vehicles with side protection rated good were found to have 70 percent fewer driver fatalities in side-impact crashes than those rated poor (Teoh and Lund 2011).

Other factors unrelated to light truck aggressivity could affect the outcome measure, the car crash partner death rate. One factor, in particular, that could have influenced the analyses

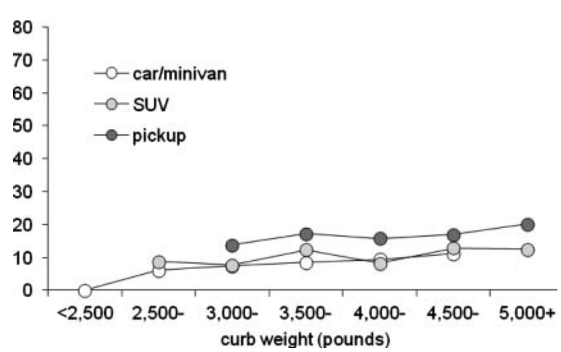

Figure 6 Car crash partner deaths in front-to-front collisions for 1- to 4-year-old vehicles per million registered vehicle years during 2008–2009.

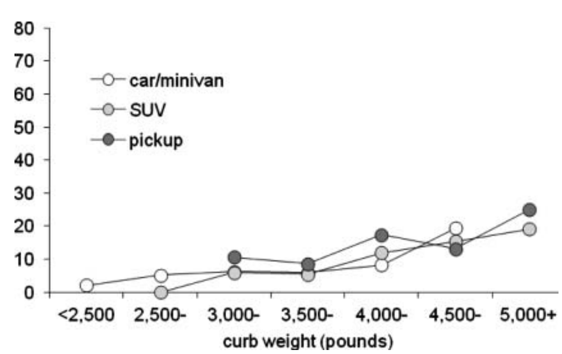

Figure 8 Car crash partner deaths in front-to-side-of-car collisions for 1- to 4-year-old vehicles per million registered vehicle years during 2008–2009.

was the economic recession and related events during the 2008–2009 portion of the study. The weak economy combined with higher gasoline prices could have disproportionately affected the use of light trucks compared to cars. Data on vehicle miles traveled (VMT) were available from the National Household Travel Survey, conducted by the Federal Highway Administration, for years 2001–2002 and 2008. Analysis of these data, accounting for changes in numbers of registered vehicles, revealed that over the time periods similar to those of the present study, the VMT of SUVs decreased by 8 percent, whereas the VMT of cars decreased by 13 percent. Pickups experienced the largest decline in VMT of 24 percent. These results are contrary to the hypothesis that SUVs look less aggressive in the analyses because of heightened gas prices or the economic recession. However, these data do not contain information on curb weight, so to evaluate this possible limitation further, car crash partner death rates were computed for 2006–2007, which preceded the economic downturn. The car crash partner death rates for cars and SUVs generally were similar to those in Figure 4, with 3500- to 3999-pound and 4000- to 4499-pound SUVs slightly higher than cars and pickups still consistently greater than both cars and SUVs. This suggests that the economic recession of 2008–2009 did not significantly affect the conclusion that SUVs, relative to cars, have become less aggressive.

Differing rates of electronic stability control (ESC) installation among different vehicle types is another source of uncertainty. Though ESC has had the largest effects on single-vehicle fatal crashes, particularly rollovers, it also has produced significant reductions in multiple-vehicle fatal crashes (Farmer 2010; Sivinski 2011). SUVs, pickups, and cars all were more likely to have ESC in the later study period than in the earlier period, but the increase in ESC fitment was largest for SUVs (IIHS 2011). Thus, it is possible that the effectiveness of ESC in multiple-vehicle crashes could account for some of the declines in the car crash partner death rate for crashes with 1- to 4-year-old SUVs in 2008–2009 relative to 2000–2001.

This study shows that modern SUVs are indiscernible from modern cars in aggressivity toward cars in front-to-front and front-to-side crashes after controlling for vehicle weight. The aggressivity of pickups has also been reduced, although not by as much as SUVs, especially in front-to-front crashes. Many major pickup models did not adhere to the EVC guidelines during the study period, and the rate of ESC fitment for pickups was also lower than for SUVs during the study period. It is likely that pickups will experience reductions in aggressivity similar to those identified for SUVs when all pickups meet the voluntary EVC design guidelines and also are fitted with ESC.

It is impossible to fully disentangle the individual contributions of the EVC agreement, the improved self-protection of cars, the increased penetration of ESC into the light truck fleet, and other factors in reducing car crash partner fatality rates. Future studies looking at specific injury types may be able to improve the understanding of how individual aspects of the EVC agreement have improved vehicles and further explore differences that remain, especially for pickups. However, this study finds that the system of regulatory testing, voluntary industry initiatives, and consumer information testing has led to a largely compatible passenger vehicle fleet if differences in vehicle mass are taken into account. The result is that lives have been saved.

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